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Design of Detection System of Quartz Wafer's Defect

Zhiyu Wang[a*], Dong Li[b], Guili Liu[c]

[a, b]*School of Photoelectronic Information & Communication Engineering, Beijing Information Science & Technology University, Beijing 100192, China*

Abstract

The natural frequency of crystal is affected by the shape of chip, minor defects will have significant impact on the natural oscillation frequency of the crystal. Therefore, the quartz wafer defect detection is an extremely important part in the component production process. In this paper, the hardware and software architecture of quartz wafer defect inspection system is introduced. Software part consists of three modules, including image acquisition, image processing and defect detection, and it is also given in VC++ code to achieve some of the functions.

*Keywords:*Quartz wafer;Image Processing;Defect detection;VC++

Introduction

As an important electronic material in the industry, the shape of quartz wafer has a direct impact on the natural frequency, minor defects will greatly impact on the natural oscillation frequency of the crystal, and ultimately affect the accuracy and reliability of the components. Therefore, quartz wafer defect detection has become a very important part in the development and production of the large-scale and ultra large-scale integrated circuit. Currently, in the domestic, the study on the technology of wafer defect detection has a slow progress, and still in the artificial stage: checking the defect of quartz wafer through visual means, which cause the test results are not uniform and vulnerable to the impact of human factors.
This article focuses on design of a quartz wafer defect detection system, which with digital image processing techniques to achieve rapid and accurate detection of defect chip.

[*] Corresponding author. Tel.:+86-13581543359.
E-mail address: wzy_328@ 163.com.

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1. Overall Design and Block Diagram of System

First of all, this system sets up an optical imaging system, to capture the target chip image, the Basic parameters of the system are as follows: The size of test chip is 8×2mm, with CCD digital camera, whose resolution is 1600×1200,Lens size is 1/1.8”, the way of lighting is dual light source 45 degrees before the lighting, instantaneous transmission rate of acquisition cards is 132MB/S. Then the collected chip images will be digitized, storage in BMP format, and encapsulated in the CDIB class, waiting for process via a new class which customizes image process.Design software and algorithms for the stored target image pre-processing, feature extraction and defect identification, and then the test results in tabular form will be stored in the Access database. The block diagram of the wafer defect detection system is shown in Fig. 1.

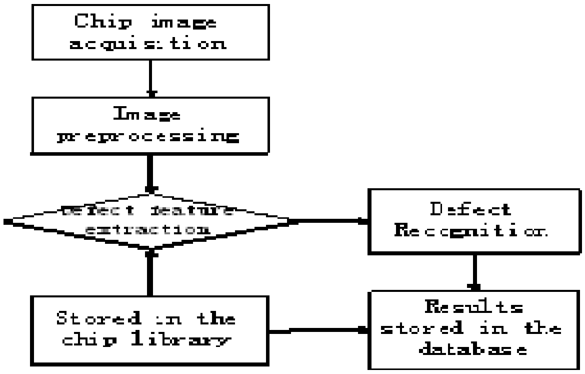

Fig. 1. Wafer defect inspection system processes

2. Design of Chip Image Preprocessing Module

As the imaging system to obtain the image (the original image) subjects to various conditions and random interference, which often cannot be used directly in the visual system, we must filter noise and enhance the image of the the original image in the early stages of visual information processing to improve image quality and ensure system performance.We must also do some pretreatment like image segmentation, edge detection according to need, then separate the original image from background, and extract details of image edge. Thepre-treatment above can ensure reliable extraction of defect characteristics of the chip, ultimately match exactly the purpose of defect. The flow chart of preprocessing module is shown in Fig. 2.

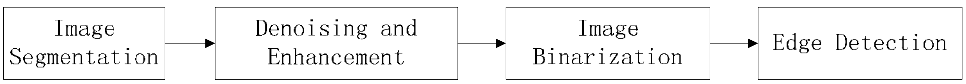

Fig. 2. Flow chart of chip pre-processing module

2.1. The segmentation of chip image

In general,the image segmentation is in the front-end of the preprocessing module, with the purpose that the background region which has nothing to do with the target can be separated from the effective area of the quartz in the quartz image, which can make follow-up treatment focu on the effective area. As this segmentation can not only improve the accuracy of defect recognition , but greatly reduce the time of the preprocessing, it is a key step from the image preprocessing to detection, and also an important part of the system. This segmentation can not only remove the invalid region as much as possible, but also as complete as possible to retain the effective area we are interested in, that means there is high requirements of the segmentation algorithm. The original image based on VC++ is shown in Fig. 3.

2.2. Image binarization

Binary image processing is to obtain 256 levels of gray scale intensity image by selectingthe appropriate threshold which can still reflect global and local features of th binary image. Collection nature of images with pixel values only in 0 or 255 points related to the location, no longer involved in multi-level pixel values, which makes processing easier, and data processing and compression smaller. In order to obtain the desired binary image, generally we use the closed, connected boundary to definite the area that not overlaps, which requests the image quality in the image pre-processing. Commonly used binarization method is based on the gray value to determine a threshold value, the pixel greater than or equal to which will be determined to object said with a gray value as a 255, the pixel less than or equal to the threshold will be determined to the background and said with a gray value 0. The image result by binarization processing is shown in Fig. 5.

2.3. Image denoising and enhancement

Image enhancement has two main objectives:First, to improve the visual effects and the clarity of the image; Second, to expend the difference between the characteristics of different objects in the images, and meet some special needs to analysis, by highlighting some interesting features, inhibiting the uninteresting features. Noise is the main factors affecting the visual effect of images. Common noise includes gaussian noise and salt and pepper noise. With a noise image quality will decline, resulting in blurred images, and even submerging feature information, making the difficulties to the image detection. As the denoising effect has a direct impact on the subsequent binarization processing and edge detection, etc, according to the characteristics of the system, I select the median filtering method, which is a non-linear smoothing, can overcome the problem blurring the image details bringing from the linear filtering under certain conditions. This method can also effective solve the problem of filtering out noise and the image noise of the scan. The result platform denoising is shown in Fig. 4.

2.4. Edge Detection

Edge of the image is the part that brightness of the local area changes significantly, the gray region of this part can be seen as a step, that means rapidly change from a small gray value in the buffer area to another that largely different in gray level. The edge of the image focus on most of information of the image, the identification and extraction of the wafer edge determine the identification and understanding of the wafer defect.

Of the traditional edge detection operator, the laplace operator often have double borders; and other operators such as Sobel operator tend to form an unclosed area. In this paper, canny operator edge detection for image will be used, with the result in Fig. 6.

3. Design of Defect Recognition Module

The process of defects identifying is actually a process that the defect characteristics match with the template image in the defect template library.

3.1. Obtain the template

First, according to the defect features of the quartz the system will detect, we should select different defective chips to make templates, which will be transformed into binary data saved to database of the wafer defect inspection system.

3.2. Template matching

The system uses sequential similarity detection algorithm (SSDA), selecting the pixel on the order of random and unrepeated on each position of the image to be matched, and adding up gray-scale difference between templates and images to be matched in the pixel, if the cumulative value is greater than a specified threshold, then location will be the non-matching position. Stopping this calculation, testing next location until you find the best matching location. SSDA can quickly discard not matching point, reduce the amount of calculation on points do not match to improve the matching speed, the algorithm is simple, and easy to implement.

3.3. Output matching results

Match the image to be tested with the defect template in the template library, then determine whether it is related to such defects, according to the degree of matching.
The result after template matching is shown in Fig. 7.

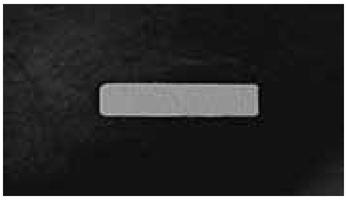

Fig. 3. Original image

Fig. 4. Binarization

Fig. 5. Median filtering

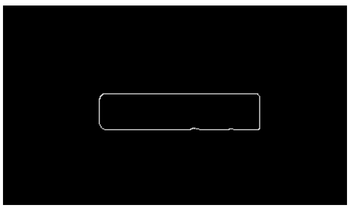

Fig. 6. Canny Edge Detection

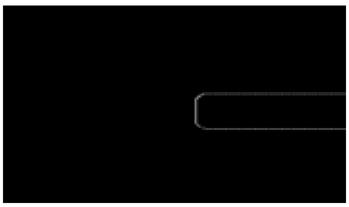

Fig. 7. Template matching

4. Conclusions

This article focuses on the design process of the quartz wafer defect inspection system, in which includes some experiments and selection for the algorithms of image processing and pattern recognition, then gives the results of each step in the process. Experimental results show that the system can achieve the quartz wafer for fast, accurate detection, which has great significance for the large-scale and ultra-large-scale production of quartz wafer. I will be in image recognition and software for further research, so that make the system with more versatility and ability of human-computer interaction.

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